

LIQUID CRYSTAL DISPLAY DEVICE AND FABRICATING METHOD THEREOF

FIELD OF THE INVENTION

This invention relates to a liquid crystal display, and more particularly to
 5 a liquid crystal display device and a fabricating method thereof wherein
 bonding characteristics between a seal and a lower plate are improved.

BACKGROUND OF THE INVENTION

Generally, a liquid crystal display (LCD) controls the amount of light
 10 transmitted from liquid crystal cells in response to video signals to thereby
 display a picture on a liquid crystal panel. The cells are typically arranged in a
 matrix pattern. The liquid crystal panel includes liquid crystal cells arranged
 in an active matrix type and driving integrated circuits (IC's) for driving the
 liquid crystal cells.

15 The driving ICs are usually manufactured in chip form and mounted on
 a tape carrier package (TCP) film attached to the outer periphery of the liquid
 crystal panel. The ICs are also connected by a tape automated bonding (TAB)
 system mounted along the outer periphery of the liquid crystal panel when the
 IC's are connected by a chips-on-glass (COG) system.

20 In the case of TAB system, the driving IC's are electrically connected to a
 pad portion disposed along an edge of the liquid crystal panel by the TCP. The
 pad portion is connected to electrode lines, which are in turn connected to each

liquid crystal cell of the liquid crystal panel, to apply driving signals generated from the driving IC's to each liquid crystal cell.

Fig. 1 is a plan view showing a structure of a conventional liquid crystal display panel. As shown, the liquid crystal panel 2 includes a lower plate 4 and an upper plate 6 bonded to each other. The liquid crystal panel 2 also includes a picture display part 8 having liquid crystal cells arranged in a matrix pattern; gate pads 12 and data pads 14 connected between driving IC's (not shown) and the picture display part 8; gate links 34 and data links 16 for connecting the gate pads 12 and the data pads 14 to the picture display part 8, respectively; and a seal 10 provided at the outer periphery of the picture display part 8 so as to bond the lower plate 4 to the upper plate 6.

Within the picture display part 8, a plurality of data lines 13 intersect with the plurality of gate lines 11 on the lower plate 4. A video signal is applied to each data line 13 via the data pad 14 and the data link 16 and a scanning signal is applied to each gate line 11 via the gate pad 12 and the gate link 34. At each intersection, each liquid crystal cell is provided with a thin film transistor (TFT) and a pixel electrode connected to the thin film transistor. The TFT provides a switching function to apply a data signal to drive the liquid crystal cell.

Red, green, and blue color filters are formed on the upper plate 6. The color filters are separated by a black matrix and a common transparent electrode is formed on the surfaces of the color filters.

The lower plate 4 and the upper plate 6 are spaced apart by a spacer to provide a constant cell gap. The lower plate 4 is bonded to the upper plate 6 by the seal 10, which is positioned along outer edges of the picture display part 8. The cell gap area is injected with liquid crystal to form the liquid crystal layer, and thereafter is sealed.

The gate pads 12 and the data pads 14 are located at the edge of the lower plate 4 not overlapped by the upper plate 6. Each gate pad 12 applies a scanning signal from the gate driving IC to the gate line 11 via a wire within the TCP film and the gate link 34. Also, each data pad 14 applies a video data signal from the data driving IC to the data line 13 via the data link 16.

In the conventional liquid crystal panel 2 as described above, a protective film is coated on the entire lower plate 4 to protect the metal electrode lines and the thin film transistors. Also the pixel electrode, which is connected via a contact hole to the TFT, is formed on the protective film for each cell area. The pixel electrode is a transparent electrode made from indium tin oxide (ITO), which has a relatively strong durability.

Generally, an inorganic material such as SiN_x or SiO_x is used as the protective film. These typically have high dielectric constants. Because of the high dielectric constants, the conventional liquid crystal with inorganic protective films suffers from a coupling effect caused by an increase in parasitic capacitance between the pixel electrode and the data line 13.

A way to minimize the coupling effect is to keep the two electrodes at a relatively long distance, for example, of 3 to 5 μm so that the pixel electrode

dose not overlap with the data line 13. However, due to the increased spacing, it is necessary to form an area of the pixel electrode applying a voltage to the liquid crystal layer to be as narrow as possible. In such instance, aperture ratio of the liquid crystal cell, which depends on the area of the pixel electrode, is reduced.

A way to overcome this problem, i.e. minimize the coupling effect but still achieve higher aperture ratio, is to use protective films made of organic materials. Organic materials such as benzocyclobutene (BCB), spin on glass (SOG), or Acryl, have relatively low dielectric constants. Due to the low dielectric constants, the area of the pixel electrode can be enlarged to improve aperture ratios of the liquid crystal cell.

Unfortunately, a high aperture ratio LCD employing the organic protective film suffers from problems of its own. When bonding the upper and lower plates, a seal is used. As shown in Fig. 1, the seal 10 makes contact with the organic protective film (shown in Figs. 3A and 3B) as the plates are bonded.

Typically, epoxy resin is used as the seal. Such seal strongly adheres to inorganic protective films and glass substrates, but weakly adheres to organic materials such as the organic protective film. Thus, the high aperture ratio LCD employing the organic protective film is much more likely to develop leakage problems when the liquid crystal panel is subjected to physical stresses such as an impact.

In addition, the conventional LCD typically has a gate insulating layer disposed between the glass substrate and the organic protective film.

Unfortunately, an organic protective film has poor adherence to the gate insulating film as well. Accordingly, a crack may be generated between the organic protective film and the gate insulating film due to physical stresses. As a result, the organic protective film could be floating or the liquid crystal may
 5 leak. Such problems of the conventional liquid crystal are described in further detail with reference to the accompanying drawings.

Fig. 2 is an enlarged plan view showing a crossing portion between the data link and the seal in Fig. 1. As shown, the data link 16 is formed along with the data pad 14 and the data line 13. A semiconductor layer 18 extends from the data line 13 into the data pad 14 at the lower portion of the data link 16. The seal 10 is located on the organic protective film in a direction crossing the data link 16. The data pad 14 contacts a transparent electrode 17 on the organic protective film through a contact hole 19 defined in the organic protective film. The transparent film 17 is connected to the data driver IC
 10
 15
 20
 25
 30
 35
 40
 45
 50
 55
 60
 65
 70
 75
 80
 85
 90
 95
 100
 105
 110
 115
 120
 125
 130
 135
 140
 145
 150
 155
 160
 165
 170
 175
 180
 185
 190
 195
 200
 205
 210
 215
 220
 225
 230
 235
 240
 245
 250
 255
 260
 265
 270
 275
 280
 285
 290
 295
 300
 305
 310
 315
 320
 325
 330
 335
 340
 345
 350
 355
 360
 365
 370
 375
 380
 385
 390
 395
 400
 405
 410
 415
 420
 425
 430
 435
 440
 445
 450
 455
 460
 465
 470
 475
 480
 485
 490
 495
 500
 505
 510
 515
 520
 525
 530
 535
 540
 545
 550
 555
 560
 565
 570
 575
 580
 585
 590
 595
 600
 605
 610
 615
 620
 625
 630
 635
 640
 645
 650
 655
 660
 665
 670
 675
 680
 685
 690
 695
 700
 705
 710
 715
 720
 725
 730
 735
 740
 745
 750
 755
 760
 765
 770
 775
 780
 785
 790
 795
 800
 805
 810
 815
 820
 825
 830
 835
 840
 845
 850
 855
 860
 865
 870
 875
 880
 885
 890
 895
 900
 905
 910
 915
 920
 925
 930
 935
 940
 945
 950
 955
 960
 965
 970
 975
 980
 985
 990
 995
 1000
 1005
 1010
 1015
 1020
 1025
 1030
 1035
 1040
 1045
 1050
 1055
 1060
 1065
 1070
 1075
 1080
 1085
 1090
 1095
 1100
 1105
 1110
 1115
 1120
 1125
 1130
 1135
 1140
 1145
 1150
 1155
 1160
 1165
 1170
 1175
 1180
 1185
 1190
 1195
 1200
 1205
 1210
 1215
 1220
 1225
 1230
 1235
 1240
 1245
 1250
 1255
 1260
 1265
 1270
 1275
 1280
 1285
 1290
 1295
 1300
 1305
 1310
 1315
 1320
 1325
 1330
 1335
 1340
 1345
 1350
 1355
 1360
 1365
 1370
 1375
 1380
 1385
 1390
 1395
 1400
 1405
 1410
 1415
 1420
 1425
 1430
 1435
 1440
 1445
 1450
 1455
 1460
 1465
 1470
 1475
 1480
 1485
 1490
 1495
 1500
 1505
 1510
 1515
 1520
 1525
 1530
 1535
 1540
 1545
 1550
 1555
 1560
 1565
 1570
 1575
 1580
 1585
 1590
 1595
 1600
 1605
 1610
 1615
 1620
 1625
 1630
 1635
 1640
 1645
 1650
 1655
 1660
 1665
 1670
 1675
 1680
 1685
 1690
 1695
 1700
 1705
 1710
 1715
 1720
 1725
 1730
 1735
 1740
 1745
 1750
 1755
 1760
 1765
 1770
 1775
 1780
 1785
 1790
 1795
 1800
 1805
 1810
 1815
 1820
 1825
 1830
 1835
 1840
 1845
 1850
 1855
 1860
 1865
 1870
 1875
 1880
 1885
 1890
 1895
 1900
 1905
 1910
 1915
 1920
 1925
 1930
 1935
 1940
 1945
 1950
 1955
 1960
 1965
 1970
 1975
 1980
 1985
 1990
 1995
 2000
 2005
 2010
 2015
 2020
 2025
 2030
 2035
 2040
 2045
 2050
 2055
 2060
 2065
 2070
 2075
 2080
 2085
 2090
 2095
 2100
 2105
 2110
 2115
 2120
 2125
 2130
 2135
 2140
 2145
 2150
 2155
 2160
 2165
 2170
 2175
 2180
 2185
 2190
 2195
 2200
 2205
 2210
 2215
 2220
 2225
 2230
 2235
 2240
 2245
 2250
 2255
 2260
 2265
 2270
 2275
 2280
 2285
 2290
 2295
 2300
 2305
 2310
 2315
 2320
 2325
 2330
 2335
 2340
 2345
 2350
 2355
 2360
 2365
 2370
 2375
 2380
 2385
 2390
 2395
 2400
 2405
 2410
 2415
 2420
 2425
 2430
 2435
 2440
 2445
 2450
 2455
 2460
 2465
 2470
 2475
 2480
 2485
 2490
 2495
 2500
 2505
 2510
 2515
 2520
 2525
 2530
 2535
 2540
 2545
 2550
 2555
 2560
 2565
 2570
 2575
 2580
 2585
 2590
 2595
 2600
 2605
 2610
 2615
 2620
 2625
 2630
 2635
 2640
 2645
 2650
 2655
 2660
 2665
 2670
 2675
 2680
 2685
 2690
 2695
 2700
 2705
 2710
 2715
 2720
 2725
 2730
 2735
 2740
 2745
 2750
 2755
 2760
 2765
 2770
 2775
 2780
 2785
 2790
 2795
 2800
 2805
 2810
 2815
 2820
 2825
 2830
 2835
 2840
 2845
 2850
 2855
 2860
 2865
 2870
 2875
 2880
 2885
 2890
 2895
 2900
 2905
 2910
 2915
 2920
 2925
 2930
 2935
 2940
 2945
 2950
 2955
 2960
 2965
 2970
 2975
 2980
 2985
 2990
 2995
 3000
 3005
 3010
 3015
 3020
 3025
 3030
 3035
 3040
 3045
 3050
 3055
 3060
 3065
 3070
 3075
 3080
 3085
 3090
 3095
 3100
 3105
 3110
 3115
 3120
 3125
 3130
 3135
 3140
 3145
 3150
 3155
 3160
 3165
 3170
 3175
 3180
 3185
 3190
 3195
 3200
 3205
 3210
 3215
 3220
 3225
 3230
 3235
 3240
 3245
 3250
 3255
 3260
 3265
 3270
 3275
 3280
 3285
 3290
 3295
 3300
 3305
 3310
 3315
 3320
 3325
 3330
 3335
 3340
 3345
 3350
 3355
 3360
 3365
 3370
 3375
 3380
 3385
 3390
 3395
 3400
 3405
 3410
 3415
 3420
 3425
 3430
 3435
 3440
 3445
 3450
 3455
 3460
 3465
 3470
 3475
 3480
 3485
 3490
 3495
 3500
 3505
 3510
 3515
 3520
 3525
 3530
 3535
 3540
 3545
 3550
 3555
 3560
 3565
 3570
 3575
 3580
 3585
 3590
 3595
 3600
 3605
 3610
 3615
 3620
 3625
 3630
 3635
 3640
 3645
 3650
 3655
 3660
 3665
 3670
 3675
 3680
 3685
 3690
 3695
 3700
 3705
 3710
 3715
 3720
 3725
 3730
 3735
 3740
 3745
 3750
 3755
 3760
 3765
 3770
 3775
 3780
 3785
 3790
 3795
 3800
 3805
 3810
 3815
 3820
 3825
 3830
 3835
 3840
 3845
 3850
 3855
 3860
 3865
 3870
 3875
 3880
 3885
 3890
 3895
 3900
 3905
 3910
 3915
 3920
 3925
 3930
 3935
 3940
 3945
 3950
 3955
 3960
 3965
 3970
 3975
 3980
 3985
 3990
 3995
 4000
 4005
 4010
 4015
 4020
 4025
 4030
 4035
 4040
 4045
 4050
 4055
 4060
 4065
 4070
 4075
 4080
 4085
 4090
 4095
 4100
 4105
 4110
 4115
 4120
 4125
 4130
 4135
 4140
 4145
 4150
 4155
 4160
 4165
 4170
 4175
 4180
 4185
 4190
 4195
 4200
 4205
 4210
 4215
 4220
 4225
 4230
 4235
 4240
 4245
 4250
 4255
 4260
 4265
 4270
 4275
 4280
 4285
 4290
 4295
 4300
 4305
 4310
 4315
 4320
 4325
 4330
 4335
 4340
 4345
 4350
 4355
 4360
 4365
 4370
 4375
 4380
 4385
 4390
 4395
 4400
 4405
 4410
 4415
 4420
 4425
 4430
 4435
 4440
 4445
 4450
 4455
 4460
 4465
 4470
 4475
 4480
 4485
 4490
 4495
 4500
 4505
 4510
 4515
 4520
 4525
 4530
 4535
 4540
 4545
 4550
 4555
 4560
 4565
 4570
 4575
 4580
 4585
 4590
 4595
 4600
 4605
 4610
 4615
 4620
 4625
 4630
 4635
 4640
 4645
 4650
 4655
 4660
 4665
 4670
 4675
 4680
 4685
 4690
 4695
 4700
 4705
 4710
 4715
 4720
 4725
 4730
 4735
 4740
 4745
 4750
 4755
 4760
 4765
 4770
 4775
 4780
 4785
 4790
 4795
 4800
 4805
 4810
 4815
 4820
 4825
 4830
 4835
 4840
 4845
 4850
 4855
 4860
 4865
 4870
 4875
 4880
 4885
 4890
 4895
 4900
 4905
 4910
 4915
 4920
 4925
 4930
 4935
 4940
 4945
 4950
 4955
 4960
 4965
 4970
 4975
 4980
 4985
 4990
 4995
 5000
 5005
 5010
 5015
 5020
 5025
 5030
 5035
 5040
 5045
 5050
 5055
 5060
 5065
 5070
 5075
 5080
 5085
 5090
 5095
 5100
 5105
 5110
 5115
 5120
 5125
 5130
 5135
 5140
 5145
 5150
 5155
 5160
 5165
 5170
 5175
 5180
 5185
 5190
 5195
 5200
 5205
 5210
 5215
 5220
 5225
 5230
 5235
 5240
 5245
 5250
 5255
 5260
 5265
 5270
 5275
 5280
 5285
 5290
 5295
 5300
 5305
 5310
 5315
 5320
 5325
 5330
 5335
 5340
 5345
 5350
 5355
 5360
 5365
 5370
 5375
 5380
 5385
 5390
 5395
 5400
 5405
 5410
 5415
 5420
 5425
 5430
 5435
 5440
 5445
 5450
 5455
 5460
 5465
 5470
 5475
 5480
 5485
 5490
 5495
 5500
 5505
 5510
 5515
 5520
 5525
 5530
 5535
 5540
 5545
 5550
 5555
 5560
 5565
 5570
 5575
 5580
 5585
 5590
 5595
 5600
 5605
 5610
 5615
 5620
 5625
 5630
 5635
 5640
 5645
 5650
 5655
 5660
 5665
 5670
 5675
 5680
 5685
 5690
 5695
 5700
 5705
 5710
 5715
 5720
 5725
 5730
 5735
 5740
 5745
 5750
 5755
 5760
 5765
 5770
 5775
 5780
 5785
 5790
 5795
 5800
 5805
 5810
 5815
 5820
 5825
 5830
 5835
 5840
 5845
 5850
 5855
 5860
 5865
 5870
 5875
 5880
 5885
 5890
 5895
 5900
 5905
 5910
 5915
 5920
 5925
 5930
 5935
 5940
 5945
 5950
 5955
 5960
 5965
 5970
 5975
 5980
 5985
 5990
 5995
 6000
 6005
 6010
 6015
 6020
 6025
 6030
 6035
 6040
 6045
 6050
 6055
 6060
 6065
 6070
 6075
 6080
 6085
 6090
 6095
 6100
 6105
 6110
 6115
 6120
 6125
 6130
 6135
 6140
 6145
 6150
 6155
 6160
 6165
 6170
 6175
 6180
 6185
 6190
 6195
 6200
 6205
 6210
 6215
 6220
 6225
 6230
 6235
 6240
 6245
 6250
 6255
 6260
 6265
 6270
 6275
 6280
 6285
 6290
 6295
 6300
 6305
 6310
 6315
 6320
 6325
 6330
 6335
 6340
 6345
 6350
 6355
 6360
 6365
 6370
 6375
 6380
 6385
 6390
 6395
 6400
 6405
 6410
 6415
 6420
 6425
 6430
 6435
 6440
 6445
 6450
 6455
 6460
 6465
 6470
 6475
 6480
 6485
 6490
 6495
 6500
 6505
 6510
 6515
 6520
 6525
 6530
 6535
 6540
 6545
 6550
 6555
 6560
 6565
 6570
 6575
 6580
 6585
 6590
 6595
 6600
 6605
 6610
 6615
 6620
 6625
 6630
 6635
 6640
 6645
 6650
 6655
 6660
 6665
 6670
 6675
 6680
 6685
 6690
 6695
 6700
 6705
 6710
 6715
 6720
 6725
 6730
 6735
 6740
 6745
 6750
 6755
 6760
 6765
 6770
 6775
 6780
 6785
 6790
 6795
 6800
 6805
 6810

the data links 16 are sequentially deposited on the glass substrate 20, and the organic protective film 24 covers the entire resulting surface.

Fig. 1
The upper plate 6 consists of an upper glass substrate 30, color filters (not shown), a black matrix 28, and a common, transparent electrode 26. As shown, the color filters and the black matrix 28 are formed on the upper glass substrate 30, and the common transparent electrode 26 is formed thereon.

The seal 10 bonds the lower plate 4 and the upper plate 6 to each other. As described previously, the seal 10 weakly adheres to the organic protective film 24. In addition, the organic protective film 24 weakly adheres to the gate insulating film 22 due to the inorganic nature of the gate insulating film 22. As a result, the organic floating film 24 may float or crack due to physical stresses thus causing liquid crystal 32 to leak.

Fig. 4 is an enlarged plan view showing a crossing portion between the gate link and the seal in Fig. 1. As shown, the gate link 34 is formed with the gate pad 12 and the gate line 11. The gate pads 12 contacts the transparent electrodes 17 through the contact hole 19 formed in the gate insulating film and the organic protective film. The seal 10 crosses the gate link 34.

Fig. 5A shows a vertical section of the liquid crystal display panel taken along the 5A-5A' line in Fig. 4, and Fig. 5B shows a vertical section of the liquid crystal display panel taken along the 5B-5B' line in Fig. 2. In Figs. 5A and 5B, the upper plate 6 is much like the structure as shown in Figs. 3A and 3B, respectively. The lower plate 4 is slightly different in that instead of having semiconductor layer and data link disposed between the organic protective film

24 and the gate insulating layer 22, gate link 34 is disposed between the gate insulating layer 22 and the glass substrate 20 (compare Figs. 3A and 5A).

Again because the organic protective film 24 has weak adherence to both the seal 10 and the gate insulating layer 22, leakage may develop due to
5 physical stresses.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a liquid crystal display device and a fabricating method thereof wherein bonding characteristics between seal and a lower plate is improved upon bonding of an upper plate to the lower plate, thereby preventing a leakage of liquid crystal from an exterior impact.

In order to achieve these and other objects of the invention, a liquid crystal display device according to one aspect of the present invention includes
10 an organic protective film coated on a lower plate of the liquid crystal display panel, wherein the protective film has a plurality of holes to infiltrate the seal between the electrode links; and an inorganic gate insulating film formed below
15 the organic protective film and being contacted with the seal through the holes.

A method of fabricating a liquid crystal display device according to
20 another aspect of the present invention includes the steps of removing the protective film and partially removing the gate insulating film to a predetermined thickness to define holes between the gate electrode links and

the data electrode links; and contacting the seal with the gate insulating film through the holes.

Also, a lower plate of the a liquid crystal display device according to another aspect of the present invention includes a glass plate; a gate insulating film formed over the lower glass plate wherein at least a portion of the gate
5 insulating film is etched forming an adherence surface; a protective film formed over the gate insulating film wherein a portion of the protective film above the adherence surface is completely etched to expose the adherence surface; and a seal with a contact extension portion making contact with said adherence surface.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the invention will be apparent from the following detailed description of the embodiments of the present invention with
15 reference to the accompanying drawings, in which:

Fig. 1 is a schematic plan view showing a structure of a conventional liquid crystal display panel;

Fig. 2 is an enlarged plan view of a crossing portion between the data link and the seal in Fig. 1;

20 Fig. 3A is a vertical section view of the liquid crystal display panel taken along the 3A-3A' line in Fig. 2;

Fig. 3B is a vertical section view of the liquid crystal display panel taken along the 3B-3B' line in Fig. 2;

Fig. 4 is an enlarged plan view of a crossing portion between the gate link and the seal in Fig. 1;

Fig. 5A is a vertical section view of the liquid crystal display panel taken along the 5A-5A' line in Fig. 4;

5 Fig. 5B is a vertical section view of the liquid crystal display panel taken along the 5B-5B' line in Fig. 4;

Fig. 6 is a plan view showing a structure of a portion at which data links cross a seal part in a high aperture ratio liquid crystal display device employing an organic protective film according to an embodiment of the present invention;

Fig. 7 is a section view of the liquid crystal display panel taken along the 7A-7A' line in Fig. 6 in which the organic protective film and the gate insulating film are etched to expose the lower glass substrate upon formation of the holes of Fig. 6;

Fig. 8 is a plan view showing a structure of a portion at which gate links cross a seal part in a high aperture ratio liquid crystal display device employing an organic protective film according to the embodiment of the present invention;

Fig. 9 is a section view of the liquid crystal display panel taken along the 9B-9B' line in Fig. 8 in which the organic protective film and the gate insulating film are etched to expose the lower glass substrate upon formation of the holes of Fig. 8;

Fig. 10 is a section view of the liquid crystal display panel taken along the 7A-7A' line in Fig. 6 in which the gate insulating film is partially etched upon formation of the holes of Fig. 6;

Fig. 11 is a section view of the liquid crystal display panel taken along the 9B-9B' line in Fig. 8 in which the gate insulating film is partially etched upon formation of the holes of Fig. 8;

Fig. 12 represents a plane structure of the entire substrate provided with the EPD window and the lower plate of the liquid crystal display panel;

Fig. 13 represents a plane structure of the edge and the pad of the lower plate of the liquid crystal display panel provided with the EPD window;

Fig. 14A to Fig. 14C are views for comparing a sectional structure of the EPD window area with an actual pattern area between the data and gate links to be provided with the holes;

Fig. 15 is a waveform diagram of an electrical signal proportional to a density of SiF_4 gas detected during etching; and

Fig. 16A to Fig. 16C are views for comparing a sectional structure of the EPD window area after completion of the etching work with the actual pattern area between the data and gate links.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 6 is a plan view showing a structure of a portion at which data links cross a seal part in a high aperture ratio liquid crystal display device employing an organic protective film according to an embodiment of the present invention.

Some elements and features of the liquid crystal panel are similar to those of the conventional structure. For example, the data links 52 are formed with data pads 50 and data lines. At the lower portion of the data link 52, a semiconductor layer extends from the data line to the data pad 50. The seal 54 is formed on the organic protective film in a direction crossing the data links 52. The data pads 50 are connected to a transparent electrode 60 on the organic protective film via contact holes 58 defined in the organic protective film.

As shown, holes 56 are formed in the seal 54 in between data links 52. In this embodiment, the organic protective film and the gate insulating film are etched to form the holes 56. The gate insulating film may be completely etched to expose the lower glass substrate so as to enable contact between the seal 54 and the lower glass substrate when the upper and lower plates of the liquid crystal panel are bonded.

Fig. 7 is a section view of the liquid crystal display panel taken along the 7A-7A' line in Fig. 6 in which the organic protective film and the gate insulating film are etched to expose the lower glass substrate upon formation of the holes 56 of Fig. 6. As shown, the lower plate 70 includes a glass substrate 72, a gate insulating film 74, a semiconductor layer 76, data links 52, and an organic protective film 78. The insulating film 74, the semiconductor layer 76, and the data links 52 are sequentially deposited on the glass substrate 70, and then the organic protective film 78 is coated thereon.

Also as shown, the organic protective film 78 and the gate insulating film 74 between the data links 52 are etched to form holes 56. Each hole 56 is formed by dry etching the organic protective film 78 and the gate insulating film 74 to expose the glass substrate 72. The etching is controlled using an etch point detection (EPD) window provided at the outer area of the panel (explained later).

The upper plate 80 includes an upper glass substrate 82, color filters (not shown) and a black matrix 84 formed on the upper glass substrate 82, and a common transparent electrode 86 formed entirely thereon.

The lower plate 70 and the upper plate 80 are bonded together by the seal 54. As seen in Fig. 7, the seal 54 contacts the lower glass substrate 72 via the hole 56. Since the seal 54 strongly adheres to the glass substrate 72, the bonding between upper plate 80 to the lower plate 70 is dramatically improved.

Fig. 8 is a plan view showing a structure of a portion at which gate links cross-a-seal-part in a high aperture ratio liquid crystal display device employing an organic protective film according to the embodiment of the present invention. As shown, holes 94 are formed on the seal 54 in between gate links 92.

Other elements and features of the liquid crystal panel are similar to those of the conventional structure. For example, the gate links 92 are formed with gate pads 90 and gate lines. The seal 54 is formed in a direction crossing the gate links 92 on the organic protective film of the lower plate. The gate pad



90 is connected to a transparent electrode 98 on the organic protective film via a contact hole 96.

Again, the organic protective film and the gate insulating film are etched to form the holes 94. The gate insulating film may be completely etched to
 5 expose the lower glass substrate so as to enable contact between the seal 54 and the lower glass substrate when the upper and lower plates of the liquid crystal panel are bonded.

Fig. 9 is a section view of the liquid crystal display panel taken along the 9B-9B' line in Fig. 8 in which the organic protective film and the gate insulating film are etched to expose the lower glass substrate upon formation of the holes 94 of Fig. 8. The upper plate 80 is much like the structure as shown in Figs. 7. The lower plate 70 is slightly different in that instead of having semiconductor layer and data link disposed between the organic protective film 78 and the gate insulating layer 74, gate links 92 are disposed between the gate insulating
 15 layer 74 and the glass substrate 72 (compare Figs. 7 and 9).

Also, similar to the data link part as shown in Fig. 7, the organic protective film 78 and the gate insulating film 74 between the gate links 92 are etched to form the hole 94. The hole 94 is formed by dry etching the organic protective film 78 and the gate insulating film 74 to expose the glass substrate
 20 72. This etching is controlled using the EPD technique.

As discussed above regarding Fig. 7, the lower plate 70 and the upper plate 80 are bonded together by the seal 54. As seen in Fig. 9, the seal 54 contacts the lower glass substrate 72 via the hole 94. Since the seal 54

strongly adheres to the glass substrate 72, the bonding between upper plate 80 to the lower plate 70 is dramatically improved.

Note that both the holes 56 and 94 extend beyond the edges of the seal 54. This prevents air bubbles from being generated inside the holes.

5 ~~Improvement can be made when defining the holes 56 or 94. In the~~
above embodiment, the organic protective film 78 and the gate insulating film 74 are etched to expose the lower glass substrate 72. However, during the actual etching process, a portion of the lower glass substrate 72 maybe etched as well.

10 This over-etching causes undercuts 88 to be formed as shown in Figs. 7 and 9. The undercuts 88 are physically weak points and thus are susceptible cracks from physical stresses.

Therefore, it is desirable to maintain the increased bonding characteristics and remove problems associated with the undercuts. To this
15 end, when holes are formed, only a portion of the gate insulating film is removed during the dry etching and thus the glass substrate is not exposed. In this instance, the undercuts are not generated. Also, because the seal strongly adheres to the gate insulating film, the bonding characteristics are maintained.

Fig. 10 is a section view of the liquid crystal display panel taken along
20 the 7A-7A' line in Fig. 6 in which the gate insulating film is partially etched upon formation of the holes 56. Likewise, Fig. 11 is a section view of the liquid crystal display panel taken along the 9B-9B' line in Fig. 8 in which the gate insulating film is partially etched upon formation of the holes 94. As shown in

Figs. 10 and 11, the entire organic protective film 78 and a portion of the gate insulating film 74 are etched, i.e., the holes 56 and 94 do not expose the glass substrate as in Figs. 7 and 8. Other structure and features in Figs. 10 and 11 are similar to those in Figs. 7 and 8, respectively.

5 The etching work is performed by a dry etching technique using an EPD technique (described later) to control the amount of the gate insulating film 74 that is etched. The seal 54 contacts the gate insulating film 74. Since the seal adheres strongly to the inorganic insulating film 74, bonding characteristics between the upper plate 80 and the lower plate 70 remains dramatically improved over the conventional art. Also, since the lower glass substrate 72 is not exposed, problems related to the undercuts are avoided.

10 A mechanism is needed to precisely control the amount of gate insulating film 74 etched when forming the holes 56 and 94. In a general dry etching process, reactive gases are generated from a chemical reaction between the
15 etchant and the organic protective film 78 as well as between the etchant and the gate insulating film 74. This gas generation can be monitored to control the etching process. In this embodiment, EPD window technique is used to monitor the gas generation and thus control the amount of the insulating layer that is etched.

20 Fig. 12 represents a plane structure of the entire substrate provided with EPD windows and the lower plate of the liquid crystal display panel. As shown, a plurality of lower plates 70 are provided on a large substrate 100. The lower plates are by cutting work after etching is completed. Gate lines and data lines

of a picture display part 102, a TFT of a liquid crystal cell, pads 50 and 90, and links 52 and 92 are provided on the lower plate 70.

Areas for the EPD windows 104 are positioned near the outer edge of the substrate 100. The purpose of the EPD windows is to allow for easy detection of gas generated during the etching process. To define the holes 56 and 94 between the links 52 and 92, respectively, the large substrate 100 is covered with the organic protective film 78 and a photoresist mask pattern is formed thereon. The large substrate 100 is then laid within an etching chamber.

As noted above, EPD window 104 is used to control the amount of etching. Although the EPD window 104 is etched at the same time when the holes 56 and 94 are etched, EPD window 104 is not any part of the circuitry of the LCD itself.

~~The area of the EPD window 104 is made much wider than the actual pattern area of the lower plate 70 so that reaction gas generated during etching is increase to make the detection of gas easier. The EPD window 104 is not limited to the area as shown in Fig. 12, but can be formed on a non-display part 110 of the lower plate 70 or between the pads 50 and 90 at a pad part 112, as shown in Fig. 13.~~

Figs. 14A to 14C are views for comparing a sectional structure of the EPD window area with an actual pattern area between the data and gate links to be provided with the holes. More specifically, Fig. 14A is a sectional view of the EPD window 104 while Fig. 14B and Fig. 14C are sectional views of actual pattern windows 116 in which the holes 56 and 94 are formed, respectively.

Referring to Figs. 14A to 14C, the gate insulating film 74 and the organic protective film 78 have the same thickness for each area. However, as shown in Fig. 14A, a dummy pattern 118 of a thickness t is formed below the area of the EPD window 14 on the glass substrate 72, and the gate insulating 74 is formed thereon. The thickness t represents a desired thickness of the gate insulating film 74 after the holes 56 and 94 are formed. The dummy pattern 118 is made from the same material as the gate electrode and the gate link 92.

The organic protective film 78 is evenly formed to a uniform thickness as shown in Figs. 14A to 14C by a spin coating technique. Thereafter, a photoresist pattern 120 is formed on the organic protective film 78 to provide the EPD window 104 and the actual pattern windows 116 at the data and gate link parts.

The lower glass plate 72, with the photoresist pattern 120, is then put in an etching chamber and SF_6 gas is injected into the etching chamber. As seen, the photoresist pattern 120 is such that the organic protection film 78 is exposed to the etchant gas in the EPD window area 104 and the actual pattern areas 116 where the holes 56 and 94 are to be formed.

When the etching takes place, the etchant gas reacts with Si within the organic protective film 78 to generate non-volatile SiF_4 gas. After the organic protective film 78 is etched, the gate insulating film 74 becomes exposed. The etchant then reacts with Si within the gate insulating film 74 to generate the same non-volatile SiF_4 gas.

However, when the gate insulating film 74 is etched to expose the dummy pattern below the EPD window 104, SiF_4 is no longer generated and the density of the SiF_4 gas is dramatically reduced. At this point, the desired thickness t of the gate insulating film 74, where holes 56 and 94 are defined, is
5 reached.

Thus, by monitoring the SiF_4 gas, the etching of the gate insulating film can be precisely controlled. Fig. 15 is a waveform diagram of an electrical signal proportional to a density of SiF_4 gas detected during etching. Using a gas detector, the graph as depicted in Fig. 15 can be generated. As shown, signal V_{EPD} is proportional to the density of the SiF_4 gas measured. At time t_1 , the dummy pattern 118 below becomes exposed, and the etching operation can be terminated.

Fig. 16A to Fig. 16C are views for comparing a sectional structure of the EPD window area after completion of the etching work with the actual pattern area of the holes between the data and gate links. As shown in Fig. 16A, below the EPD window 104, the organic protective film 78 and the partial gate insulating film 74 to expose the dummy pattern 118.

Because the etching rate at the EPD window 104 is equal to the etching rate at the actual pattern window 116 where the holes 56 and 94 are formed, the depth of the holes 56 (Fig. 16B) and 94 (Fig. 16C) are equal of the depth of the hole formed below the EPD window 104 (Fig. 16A). As a result, the thickness of the gate insulating film 74 where holes 56 and 94 are formed are
20 equal to the thickness of the dummy pattern 118.

Because the gate insulating film is not completely etched when the holes are formed, no undercuts are generated. Thus, when the lower and upper plates are bonded, strength of the bonding is maintained and the structural weakness is prevented.

5 As described above, in the embodiments of the present invention, holes are formed so that the seal bonds with inorganic materials such as glass substrate or the gate insulating film, which provides a dramatic improvement in bonding characteristics over the conventional art.

Further, it is possible to precisely control etching such that the gate insulating film is not completely etched when forming the holes. This prevents problems related with undercuts.

Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the 10
15
embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.